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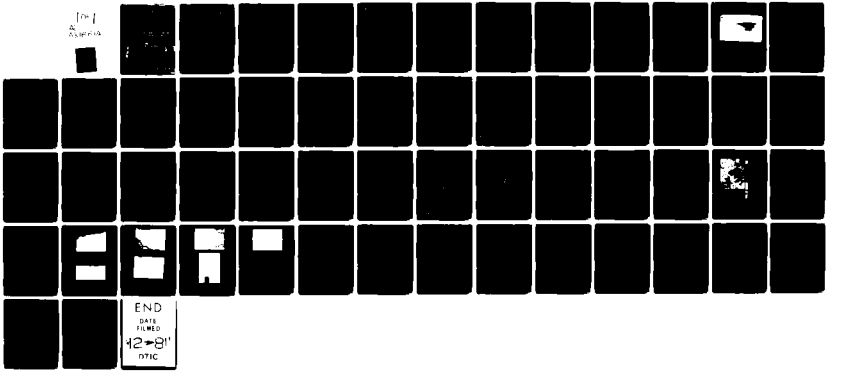

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MISSISSIPPI-KASKASKIA-ST. LOUIS BASIN

LITTLE INDIAN CREEK DAM

WASHINGTON COUNTY, MISSOURI

MO. 30718

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY INSPECTION

United States Army
Corps of Engineers
...Serving the Army
...Serving the Nation

St. Louis District

PREPARED BY: U.S. ARMY ENGINEER DISTRICT, ST. LOUIS

FOR: STATE OF MISSOURI

SEPTEMBER 1980

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Dam Safety, Lake, Dam Inspection, Private Dams

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.

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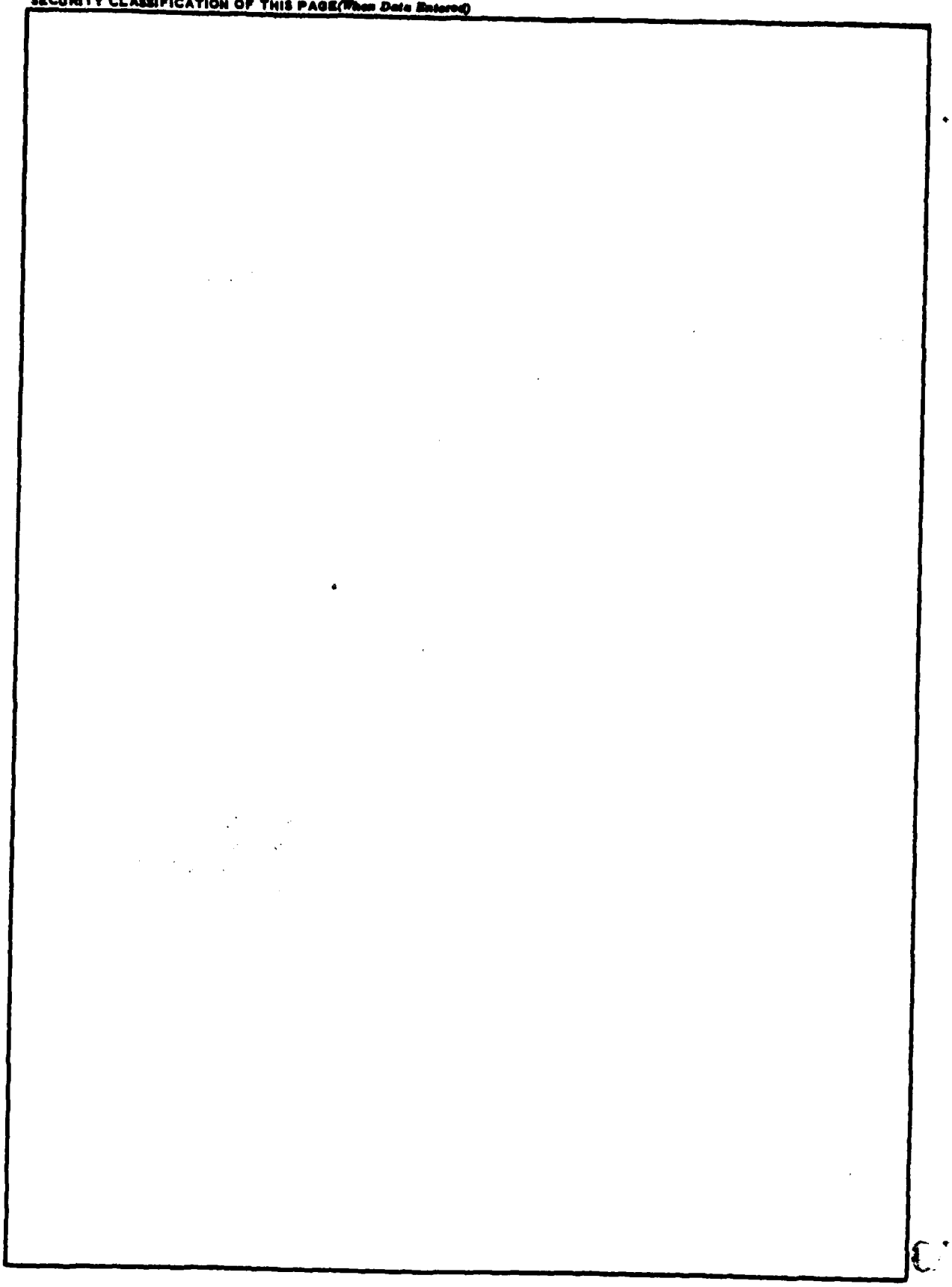

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DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 TUCKER BOULEVARD, NORTH
ST. LOUIS, MISSOURI 63101

REPLY TO ATTENTION OF

LMSED-P

SUBJECT: Little Indian Creek Dam Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Little Indian Creek Dam (MO 30718).

It was prepared under the National Program of Inspection of Non-Federal Dams.

This dam has been classified as unsafe, non-emergency by the St. Louis District as a result of the application of the following criteria:

a. This dam retains less than 50 percent of the Probable Maximum Flood without overtopping the embankment.

b. Overtopping of the embankment could result in failure of the dam.

c. Dam failure significantly increases the hazard to loss of life downstream.

SUBMITTED BY: SIGNED
Chief, Engineering Division — 29 SEP 1980 (Date)

APPROVED BY: SIGNED
Colonel, CE, District Engineer — 30 SEP 1980 (Date)

A

LITTLE INDIAN CREEK DAM

Washington County, Missouri

Missouri Inventory No. 30718

Phase I Inspection Report

National Dam Safety Program

Prepared by

Woodward-Clyde Consultants

Chicago, Illinois

Under Direction of

St Louis District, Corps of Engineers

for

Governor of Missouri

September 1980

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams for Phase I Investigations. Copies of these guidelines may be obtained from the Office of the Chief of Engineers, Washington, D. C., 20314. The purpose of a Phase I investigation is not to provide a complete evaluation of the safety of the structure nor to provide a guarantee on its future integrity. Rather the purpose of the program is to identify potentially hazardous conditions to the extent they can be identified by a visual examination. The assessment of the general condition of the dam is based upon available data (if any) and visual inspections. Detailed investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify the need for more detailed studies. In view of the limited nature of the Phase I studies no assurance can be given that all deficiencies have been identified.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with any data which may be available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action removes the normal load on the structure, as well as the reservoir head along with seepage pressures, and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through frequent inspections can unsafe conditions be detected, so that corrective action can be taken. Likewise continued care and maintenance are necessary to minimize the possibility of development of unsafe conditions.

PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam	Little Indian Creek Dam
State Located	Missouri
County Located	Washington
Stream	Unnamed tributary of Little Indian Creek
Date of Inspection	5 June 1980

Little Indian Creek Dam, Missouri Inventory Number 30718, was inspected by Richard Berggreen (engineering geologist), David Hendron (geotechnical engineer), and Sean Tseng (hydrologist). The dam is an abandoned barite tailings dam.

The dam inspection was made following the guidelines presented in the "Recommended Guidelines for Safety Inspection of Dams". These guidelines were developed by the Chief of Engineers, US Army, Washington, D.C., with the help of federal and state agencies, professional engineering organizations, and private engineers. The resulting guidelines represent a consensus of the engineering profession. They are intended to provide an expeditious identification, based on available data and a visual inspection of those dams which may pose hazards to human life or property. In view of the limited nature of the study, no assurance can be given that all deficiencies have been identified.

The St Louis District, Corps of Engineers, has classified this dam as a high hazard; we concur with this classification. The estimated damage zone extends approximately 10 mi downstream of the dam. Several vacation homes and permanent residences are located within this damage zone. The loss of life and property could be significant in the event of overtopping and failure of the dam.

The dam is classified intermediate due to its maximum height of 64 feet. The reservoir storage capacity is 578 ac-ft.

Our inspection and evaluation indicate the dam is in a generally unsatisfactory condition. This dam has no spillway or discharge channel. The cohesionless nature of the embankment materials suggest the dam would be severely eroded in the event of significant overtopping. Inclined trees on the face of the embankment indicate that some

sloughing of the face of the embankment has occurred. Mining activities at the toe of the dam have left cut faces which have reduced the apparent stability of the embankment. The downstream face of the dam appears steep, 33 to 35 degrees, and future stability of the slope is questionable if small changes occur to conditions observed during the inspection.

Hydrologic analyses indicate that precipitation events greater than 12 percent of the Probable Maximum Flood (PMF) will overtop the low point of the embankment. This is following an antecedent storm of 6 percent of the PMF. The PMF is defined as the flood event that may be expected to occur from the most severe combination of critical meterologic and hydrologic conditions that are reasonably possible in the region. A flood with 1 percent probability-of-occurrence (100 year storm) will be contained within the reservoir. The starting water surface for the 12 percent PMF storms was 805.1 ft following the antecedent storm. Starting water surface for the 50 and 100 percent PMF storms was 808.4, minimum top of dam due to the antecedent storms. Starting water surface for the 1 percent storm was the high water line of 803.4 ft.

The dam is currently abandoned and there are no maintenance or inspection programs.

It is recommended that the following studies be made and the following actions be taken, under the guidance of an engineer experienced in the design and construction of dams:

1. Construct a spillway to minimize storage behind the dam and to pass the appropriate design flood.

2. Construct a discharge channel so that erosion of the toe of the embankment will not occur.

3. Make seepage and stability analyses of the dam comparable to those required in the recommended guidelines. These analyses should be made for appropriate loading conditions, including earthquake loads.

4. Implement a program of periodic inspections to detect any changes in seepage rate and turbidity of seepage water and to identify areas of slope instability, such as slumping and erosion of the face of the dam.

It is suggested the owner takes action on those recommendations without undue delay to avoid further deterioration of this structure which could lead to the development of unsafe emergency conditions.

WOODWARD-CLYDE CONSULTANTS

Richard G. Berggreen
Registered Geologist

Stanley F. Gizienski, P.E.
Vice-President

OVERVIEW
LITTLE INDIAN CREEK DAM

MISSOURI INVENTORY NUMBER 30718

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
LITTLE INDIAN CREEK DAM - INVENTORY NO. 30718

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PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
LITTLE INDIAN CREEK DAM, INVENTORY NO. 30718

SECTION 1
PROJECT INFORMATION

1.1 General

a. **Authority.** The National Dam Inspection Act, Public Law 92-367, provides for a national Inventory and inspection of dams throughout the United States. Pursuant to the above, an inspection was conducted of the Little Indian Creek Dam, Missouri Inventory number 30718.

b. **Purpose of inspection.** "The primary purpose of the Phase I investigation program is to identify expeditiously those dams which may pose hazards to human life or property... The Phase I investigation will develop an assessment of the general condition with respect to safety of the project based upon available data and a visual inspection, determine any need for emergency measures and conclude if additional studies, investigations and analyses are necessary and warranted." (Chapter 3, Recommended Guidelines for Safety Inspection of Dams).

c. **Evaluation criteria.** The criteria used to evaluate the dam were established in the "Recommended Guidelines for Safety Inspection of Dams"; "Engineering Regulation No. 1110-2-106 and Engineering Circular No. 1110-2-188", Engineering and Design National Program for Inspection of Non-Federal Dams, prepared by the Office of Chief of Engineers, Department of the Army, and "Hydrologic/Hydraulic Standards, Phase I Safety Inspection of Non-Federal Dams" prepared by the St Louis District, Corps of Engineers (SLD). These guidelines were developed with the help of several federal agencies and many state agencies, professional engineering organizations, and private engineers.

1.2 Description of Project

a. **Description of dam and appurtenant structures.** Little Indian Creek Dam is an abandoned tailings dam. Its construction procedure and usage are typical of other barite tailings dam in the area but are not typical of dams constructed for the impoundment of water. The unique nature of these tailings dams has a significant impact on their evaluation. A brief description of the general construction procedure and usage of Missouri barite tailings dams is necessary to understand the unique nature of these dams, and understand the differences between these dams and conventional water-retaining dams.

At the start of a barite mining operation in this area, a 10 to 20-ft high starter dam is usually first constructed across a natural stream channel. Generally the streams are intermittent so that construction is carried out in the dry. Trees and other vegetation are removed from the dam site and then a cutoff is often made to shallow bedrock. Locally obtained earth, usually a gravelly clay, is then placed to form the embankment. Compaction is limited to that provided by the equipment.

The barite ore is contained within the residual gravelly clay which is mined with earth-moving equipment. At the processing plant, the ore is washed to loosen and remove the soil. This water is obtained from the reservoir area behind the dam. The soil-laden, wash water (and water from other steps in the process) is then discharged into the reservoir. There, the soil is deposited by sedimentation and the water recycled. Another step in the process removes the broken gravel-sized waste which is called "chat".

As the level of the fine tailings increases, the dam is raised. The usual method is to dump chat on the dam crest. The chat is spread over the crest so that a relatively constant crest width is maintained as the dam is raised. Generally the crest centerline location is also maintained. However, the crest centerline location may migrate upstream if there is insufficient chat available and downstream if an excessive quantity of chat is available. The latter is uncommon, because it is indicative of a poor ore deposit.

This method of construction results in embankment slopes which are close to the natural angle of repose for the chat. They can be considered to be near a state of incipient failure.

A large quantity of water is required for a barite processing, on the order of 2000 to 5000 gal/min. Thus, it has been the operators' practice to construct the dam so that all inflow to the reservoir is recycled in order to have sufficient water for the operation. The result is that formal spillways or regulating outlets are generally not constructed. In most cases, a low point on or near the dam is provided for overflow, should the storage capacity be exceeded.

The fine tailings typically fill more than 80 percent of the total storage volume. This results from the operator's practice of maintaining only a 2 to 5 ft elevation differential between the level of the tailings and the dam crest. The differential is usually greater further away from the discharge point and also typically further away from the dam.

The geotechnical characteristics of the fine tailings are somewhat similar to recent lacustrine clay deposits. Where the tailings have been continuously submerged, they have a very soft consistency and high water contents. When evaporation causes the water level to recede and the tailings are exposed, a stiff crust forms as the tailings dry out. Below the crust, the tailings retain their soft consistency for long periods of time. This consistency is very gradually modified by a slow process of consolidation.

Little Indian Creek Dam is generally representative of barite tailings dams. The dam has no spillway or discharge channel. The controlling elevation for overflow from this dam appears to be approximately at el 808 ft (MSL) near the north end of the embankment. An outlet pipe was found through the embankment near the southwest corner, but was at el 814 ft (MSL), above the overflow point on the crest of the dam. No control structures exist at the overflow area to control flows.

b. **Location.** The dam is located on an unnamed tributary of Little Indian Creek, approximately 0.5 mi southeast of the town of Richwoods in Washington County, Missouri, Mineral Land Survey #3020, T40N, R2E; (Fig. 1), USGS Richwoods NE 7.5 minute quadrangle map.

c. **Size classification.** The dam is classified as intermediate size due to its maximum height of 64 feet. The storage capacity of the reservoir is 578 ac-ft.

d. **Hazard classification.** The St Louis District, Corps of Engineers has classified this dam high hazard; we concur with this classification. The estimated damage zone extends approximately ten miles downstream of the dam. Within this damage zone are nine dwellings and several trailers.

e. **Ownership.** We understand the dam is owned by Desoto Mining Co, Box 35, Richwoods, Missouri, 63071. Correspondence should be addressed to Mr Durward Spees.

f. **Purpose of dam.** The dam was constructed to impound fine barite tailings produced by washing of barite ore mined in the vicinity. Water was recycled from the reservoir and used in the barite processing operations. The dam is currently abandoned.

g. **Design and construction history.** The present owner has no records of the design or construction of the dam. A former owner was located (Mr J. E. Politte) and he indicated the dam was started 30 to 40 years ago but could not recall the original owner. His company, Politte Brothers Mining Co, took over operations in 1961 or 1962, used the pond and added to the height of the dam. Operations ended in 1971 or 1972, and the pond has been inactive since then. We understand Desoto Mining Co currently owns the property. Mr R. L. Davidson of Desoto Mining Co said there are no present plans to reactivate the pond.

h. **Normal operating procedures.** No operating records were found for this facility.

1.3 Pertinent Data

a. **Drainage area.** Approximately 0.63 mi^2

b. **Discharge at damsite.**

Maximum known flood at damsite	Unknown
Warm water outlet at pool elevation	N/A
Diversion tunnel low pool outlet at pool elevation	N/A
Diversion tunnel outlet at pool elevation	N/A
Gated spillway capacity at pool elevation	N/A
Gated spillway capacity at maximum pool elevation	N/A
Ungated spillway capacity at maximum pool elevation	No spillway
Total spillway capacity at maximum pool elevation	No spillway

c. **Elevation (ft above MSL).**

Top of dam	808.4 to 817.0
Maximum pool-design surcharge	N/A
Full flood control pool	N/A
Recreation pool	N/A
Spillway crest (gated)	N/A
Upstream portal invert diversion tunnel	N/A
Downstream portal invert diversion tunnel	N/A
Streambed at centerline of dam	Unknown
Maximum tailwater	N/A
Toe of dam at maximum section	750.8

d. **Reservoir.**

Length of maximum pool	Approximately 1925 ft
Length of recreation pool	N/A
Length of flood control pool	N/A

e. **Storage (acre-feet).**

Recreation pool	N/A
Flood control pool	N/A
Design surcharge	N/A
Top of dam	578 (this volume does not include the volume occupied by the fine tailings impounded by the dam)

f. **Reservoir surface (acres).**

Top of dam	48
Maximum pool	48
Flood control pool	N/A
Recreation pool	N/A
Spillway crest	N/A

g. **Dam.**

Type	Barite tailings
Length	Approximately 1685 ft
Height	Approximately 64 ft
Top width	20 to 30 ft
Side slopes	Downstream 1.5(H) to 1(V); Upstream Unknown
Zoning	Unknown (probably none)
Impervious core	Unknown (probably none)
Cutoff	Unknown (probably to shallow rock surface)
Grout curtain	Unknown (probably none)

h. **Diversion and regulating tunnel.**

Type	None
Length	N/A
Closure	N/A
Access	N/A
Regulating facilities	None

i. **Spillway.**

Type	No spillway
Length of weir	N/A
Crest elevation	N/A
Gates	N/A
Downstream channel	Flow runs intermittently through a relatively flat, open, rural area.

j. **Regulating outlets.** None

SECTION 2
ENGINEERING DATA

2.1 Design

No design data or other engineering data are known to exist.

2.2 Construction

No construction records are known to exist. Construction is apparently typical of barite dams in the area. See Section 1.2a.

2.3 Operation

No operation records are known to exist.

2.4 Evaluation

a. **Availability.** No engineering data were available for review.

b. **Adequacy.** The field survey and visual inspection conducted for this report and presented herein, are considered adequate to support to conclusions of this Phase I report.

Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record. These analyses should be performed by an engineer experienced in the design and construction of dams.

c. **Validity.** Not applicable.

2.5 Project Geology

The dam site lies on the northern flank of the Ozark structural dome. The regional dip is to the north. The bedrock in the area is mapped as Cambrian age Eminence and Potosi dolomite formations on the Geologic Map of Missouri (Fig. 4). The Potosi Formation is a medium- to fine-grained, light gray dolomite, and typically contains an abundance of quartz druse characteristic of chert bearing formations. The Eminence Formation comformably overlies the Potosi Formation, and is similar in appearance but contains less quartz and chert. Some caves and large springs have been found in the Eminence in parts of Missouri; however, at the site, no evidence of solution activity was noted during the field inspection.

The soil at the dam site is a dark red-brown, plastic residual clay (CH), characteristically developed on the Potosi Formation. It is locally overlain by 1 to 5 ft of silty loess (ML). The area is mapped on the Missouri General Soils Map as Union-Goss-Gasconade-Peridge Association.

The Richwoods Fault zone lies approximately 2 mi south of the dam site and is mapped on the Structural Features Map of Missouri (1971) as discontinuous for approximately 19 mi, in a WNW-ESE direction. The Ditch Creek Fault System is located about 3 mi north of the site and is mapped on the Structural Features map as approximately 11 mi long, paralleling the Richwoods Fault zone. The Ditch Creek System is mapped as north side down; the Richwoods fault is mapped as north side up. These faults are Pre-Cambrian in age and are not in a seismically active area. They are not considered to pose a significant hazard to the dam.

SECTION 3
VISUAL INSPECTION

3.1 Findings

a. **General.** Dam was inspected on 5 June 1980 without the owner's representative present. This inspection indicated the dam was in a generally unsatisfactory condition.

b. **Dam.** Little Indian Creek Dam consists of coarse tailings locally referred to as "chat". This material is sandy gravel and sand (GW, SW). It is cohesionless and permeable, and would likely be severely eroded if the dam were overtopped.

The slope on the face of the dam has an angle of 33 to 35 degrees, which is probably very close to the natural angle of repose for this material.

There was no evidence of horizontal or vertical displacement of the dam crest alignment. No evidence of serious erosion, detrimental settlement, cracking, animal burrows, depressions or sinkhole development was noted during the visual inspection.

Seepage noted along the toe of the left abutment (as the observer faces downstream) was estimated at about 5 gal/min. Away from the toe of the dam, the small stream which collects both seepage and overland runoff was estimated to be carrying about 15 gal/min. The seepage water did not appear to be carrying any fine soil particles.

Near the right abutment, mining activities have extended to the toe of the dam (Photo 1), and left a near vertical cut (6 to 7 ft in height) near the toe of the dam.

Vegetation on the face of the dam consists of scattered bush and small to moderate size trees. Several of the trees appear to be inclined downhill, suggesting some surface sloughing may have occurred on the face of the dam.

However, no evidence of currently active or recent slope movements was noted during the site inspection.

c. **Appurtenant structures**

1. Spillway. This dam has no spillway or discharge channel. In the event that the reservoir would become filled, discharge would occur at the low point in the dam crest near the north abutment. Elevation of this low point was surveyed at 808.4 ft (MSL). No reports or other evidence of overflow was identified during the visual inspection.

2. Overflow pipe. A 8 in. pipe is buried in the dam, about 4 ft below the dam crest as shown in Fig. 3B and Photo 5. There are no controls on the pipe. The pipe is above the elevation where overtopping of the dam crest near the north abutment would occur, and is therefore of no value prior to overtopping.

d. **Reservoir area.** Approximately 60 percent of the impoundment surface area was above the water level at the time of inspection. This area is underlain by tailings which consist primarily of a relatively impervious mixture of sand, silt and clay. Low brushy vegetation is growing on the tailings.

Slopes surrounding the reservoir area are relatively flat and estimated to be less than 10 (H): 1 (V). No indication of potential instability of these slopes was observed, at the time of the inspection.

e. **Downstream channel.** The channel below the dam flows through a relatively flat, open, rural area. It is an intermittent stream. No reports or other evidence of overflow was identified during the visual inspection.

3.2 Evaluation

Our evaluation indicates the dam is in a generally unsatisfactory condition. There is evidence of some surface sloughing on the downstream slope. Seepage at present does not contain soil particles and is not excessive, but could increase in the future and cause further slope instability.

There is no spillway in this dam. In view of the cohesionless nature of the embankment materials and the steep downstream face of the dam, overtopping could result in serious erosion and failure of the embankment.

Further mining at the toe of the slope could result in slope failures on the face of the embankment.

SECTION 4
OPERATIONAL PROCEDURES

4.1 Procedures

No operating procedures currently exist as the dam has been abandoned.

4.2 Maintenance of Dam and Spillway

No maintenance is performed as the dam has been abandoned. There is no evidence of any planned maintenance in the future. The dam has no spillway or discharge channel.

4.3 Maintenance of Operating Facilities

Not applicable.

4.4 Description of Any Warning System in Effect

The visual inspection did not identify any warning system in effect at this dam.

4.5 Evaluation

There is no evidence of any plan for periodic inspections and performance of maintenance. In view of the abandoned nature of the dam, the lack of spillway, and the erodibility of the embankment, the dam could erode and deteriorate to an unsafe condition with time without being noticed. The lack of a warning system is also considered a deficiency for the conditions observed.

SECTION 5
HYDRAULIC/HYDROLOGIC

5.1 Evaluation of Features

a. **Design data.** No hydrologic or hydraulic design information was available for evaluation of this reservoir and dam. Pertinent dimensions of the dam and reservoir were surveyed on 5 June 1980, measured during the visual inspection or estimated from USGS topographic maps. The map used in the analysis is the USGS Richwoods NE 7.5 minute quadrangle map.

b. **Experience data.** No recorded history of rainfall, runoff, discharge, or pool stage data were available for this reservoir and dam.

c. **Visual observations.** Little Indian Creek Dam is an abandoned tailings dam. No designed spillway was identified during the visual inspection. A pipe was located near the west end of the embankment, but surveyed elevations indicate the dam would be overtopped before the pipe carried any flow. Other observations regarding the reservoir, dam, or spillway are presented in Section 3, Visual Inspection.

Seepage through the embankment noted during the visual inspection is not hydrologically significant in the overtopping analysis.

d. **Overtopping potential.** The overtopping potential hydrologic analysis for this dam was performed using the "HEC-1, Dam Safety Version" (1 April 1980) computer program. The method used, the data and output summaries are presented in Appendix B. The analyses show that the dam would be overtopped by any hydrologic event greater than 50 percent of the Probable Maximum Flood (PMF). However, the 1 percent probability-of-occurrence (100-year flood) event would be contained in the tailings pond impoundment without overtopping the dam.

Since the dam is made of erodible materials, overtopping could result in substantial erosion of the embankment. Substantial erosion could lead to failure of the dam.

The dam will be overtopped by a storm of greater than 12 percent of the PMF (following an antecedent storm of 6 percent of the PMF).

The PMF is defined as the flood event which may be expected to occur from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region.

The following results were obtained for the dam from the hydrologic/hydraulic analyses summarized in Appendix B:

Precipitation Event	Max Reservoir W.S. Elev. ft (MSL)	Max Depth of Overtopping ft	Max Outflow ft^3/sec	Duration of Overtopping hrs
12% PMF	808.4	0	0	0
50% PMF	810.7	2.3	1278	48
100% PMF	811.4	3.0	2628	48

The antecedent storm for the 12 percent PMF event (½ of that storm or equal to 6 percent PMF) was calculated to produce a starting water surface for the 12 percent routing of 805.1 ft. The starting water surface for the 50 and 100 percent PMF routings was equal to the minimum top of dam, 808.4 ft.

SECTION 6
STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. **Visual observations.** Visual observations which adversely affect the structural stability of this dam are reported in Section 3. Features of specific note include the lack of a spillway and discharge channel; evidence of sloughing on the face of the dam, and mining cut faces at the toe of the dam.

b. **Design and construction data.** No design or construction data relating to the structural stability of the dam were found. In particular, seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

c. **Operating records.** No appurtenant structures requiring operation exist at this dam.

d. **Post construction changes.** Post-construction changes are apparently limited to the mining activities at the toe of the dam (Photo 1).

e. **Seismic stability.** The dam is in Seismic Zone 2, to which the guidelines assign a moderate damage potential. Since no static stability analysis is available for review, the seismic stability cannot be evaluated. However, as the tailings are fine-grained, saturated materials and the dam is made of loose, granular material, substantial deformation damage or failure could occur in the event of a severe seismic event.

SECTION 7
ASSESSMENT/REMEDIAL MEASURES

7.1 Dam Assessment

a. **Safety.** Based on the visual inspection, Little Indian Creek Dam appears to be in a generally unsatisfactory condition.

As a consequence of the widely-used procedure for construction of barite tailings dams, the slopes of the dams are placed at the angle of natural repose for the material. This results in slopes which are very steep and exist near incipient failure with safety factors approximately equal to one. Gradual improvement of the factor of safety against overall slope failure can be expected with time, as consolidation and desiccation of the impounded fine-grained tailings increase their strength and decrease the driving forces acting on the embankment.

The slopes placed at the angle of natural repose will only remain stable if they are protected against changes that will increase load or decrease strength. Such changes include but may not be limited to the following:

1. Overtopping by water.

2. Higher pore pressures (or seepage forces).

3. Undercutting of the toe of the slope by erosion or mining activity.

4. Increase in the height of the slope (applicable to active operations).

5. Liquefaction (such as may result from a seismic event).

The first four changes are subject to control by owners and operators and must receive careful attention to maintain stable dam embankments. The fifth influence represents a risk, the magnitude of which cannot be estimated without further study.

b. **Adequacy of information.** Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available; this precludes an evaluation of the structural and seismic stability of the dam. The lack of these analyses is considered a deficiency.

c. **Urgency.** The deficiencies described in this report could affect the safety of the dam. Corrective actions should be initiated without undue delay.

d. **Necessity for Phase II.** In accordance with the "Recommended Guidelines for Safety Inspections of Dams", the subject investigation was a minimum study. This study revealed that additional in-depth investigations are needed to complete the assessment of the safety of the dam. Those investigations which should be performed without undue delay are described in Section 7.2.b. It is our understanding from discussions with the St Louis District that any additional investigations are the responsibility of the owner.

7.2 Remedial Measures

a. **Alternatives.** There are several general options available which may be considered to reduce the possibility of dam failure or to diminish the harmful consequences of such a failure. Some of these options are:

1. Remove the dam, or breach it to prevent storage of water.

2. Increase the height of the dam and/or construct a spillway adequate to pass the Probable Maximum Flood without overtopping the dam.

3. Purchase downstream land that would be adversely impacted by dam failure and restrict human occupancy.

4. Enhance the stability of the dam to permit overtopping by the Probable Maximum Flood without failure.

5. Provide a highly reliable flood warning system (generally does not prevent damage but decrease chances of loss of life).

b. **Recommendations.** Based on our inspection of Little Indian Creek Dam, it is recommended that further study be conducted without undue delay, under the guidance of an engineer experienced in the design and construction of dams, to evaluate, as a minimum:

1. Design and construction of a spillway and discharge channel of adequate capacity. Location and capacity of discharge channel should be such as to inhibit potential erosion at the toe of embankment.

2. The establishment of an effective, practical warning system for advising downstream residents should unsafe conditions develop at the facility.

c. **Operation and maintenance procedures.** A program of periodic inspections should be initiated to identify evidence of slope instability and increases in the amount of seepage flow or turbidity of the seepage water. Reports of inspections and any recommended maintenance should be made a matter of record.

REFERENCES

Allgood, Ferris P., and Persinger, Ivan, D., 1979, "Missouri General Soil Map and Soil Association Descriptions," US Department of Agriculture, Soil Conservation Service and Missouri Agricultural Experiment Station.

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Hydrologic Engineering Center, US Army Corps of Engineers, 1978, "Flood Hydrograph Package (HEC-1) Users Manual for Dam Safety Investigations".

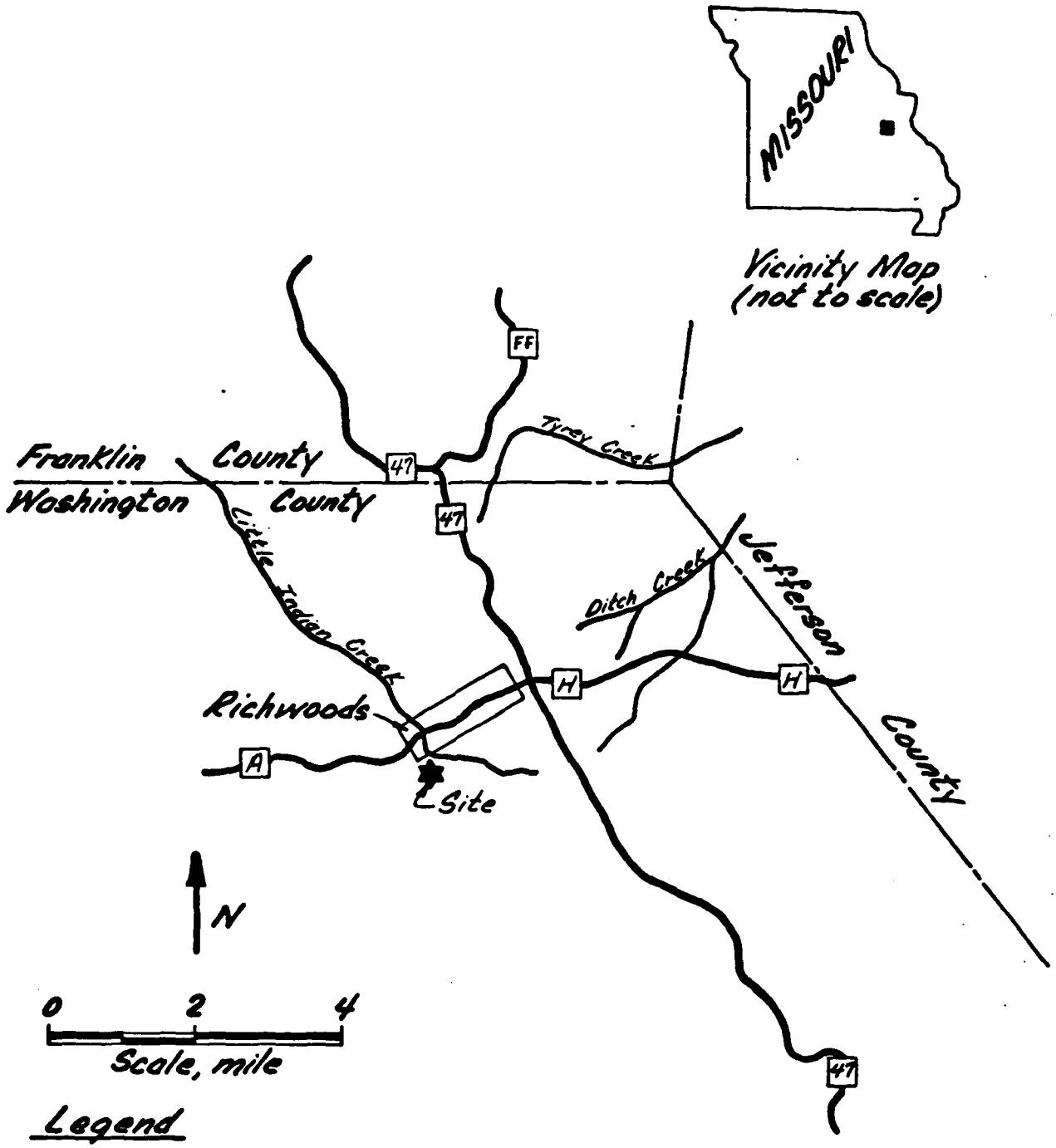
McCracken, Mary H., 1971, Structural Features Map of Missouri: Missouri Geological Survey, Scale 1:500,000.

Missouri Geological Survey, 1979, Geologic Map of Missouri: Missouri Geological Survey, Scale 1:500,000.

St Louis District, US Army Corps of Engineers, 1979, "Hydrologic/Hydraulic Standards, Phase I Safety Inspection of Non-Federal Dams".

US Department of Commerce, US Weather Bureau, 1956, "Seasonal Variation of the Probable Maximum Precipitation East of the 105th Meridian for Areas from 10 to 1,000 Square Miles and Durations of 6, 12, 24 and 48 Hours," Hydrometeorological Report No. 33.

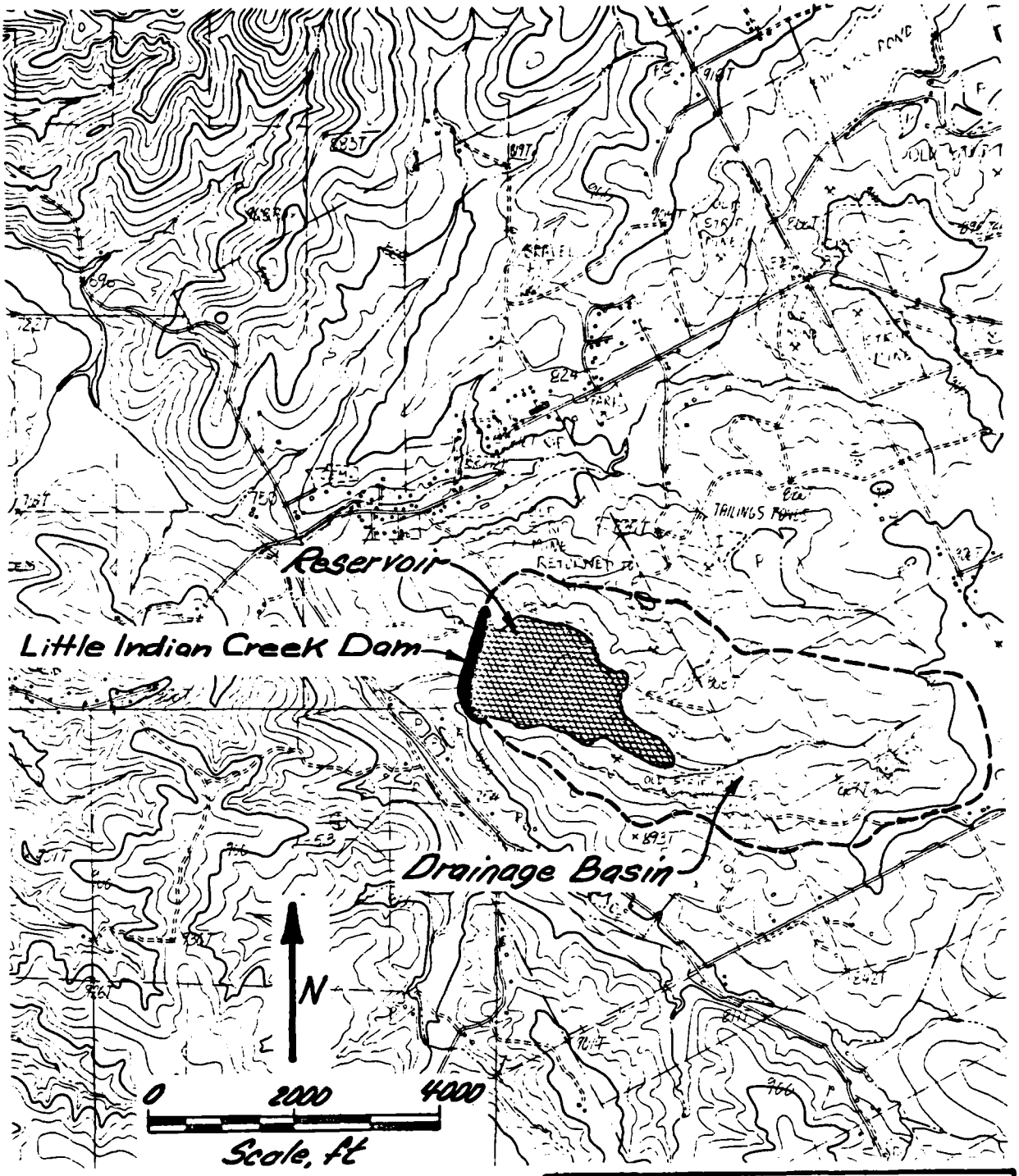
US Soil Conservation Service, 1971, "National Engineering Handbook," Section 4, Hydrology, 1971.



SITE LOCATION MAP

LITTLE INDIAN CREEK DAM

MO. 30718 | Fig. 1

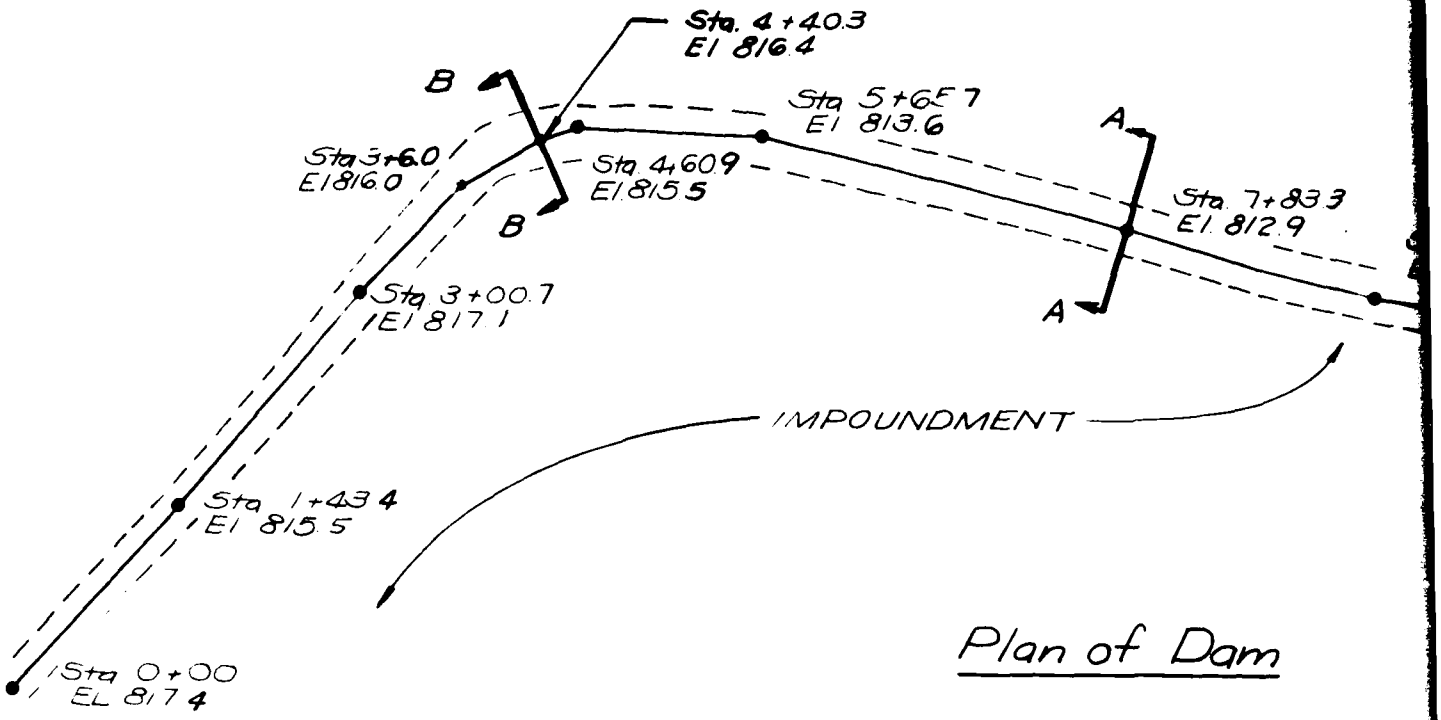


1. Topography from U.S.G.S. Richwoods NE 7½ minute quad. angle map.

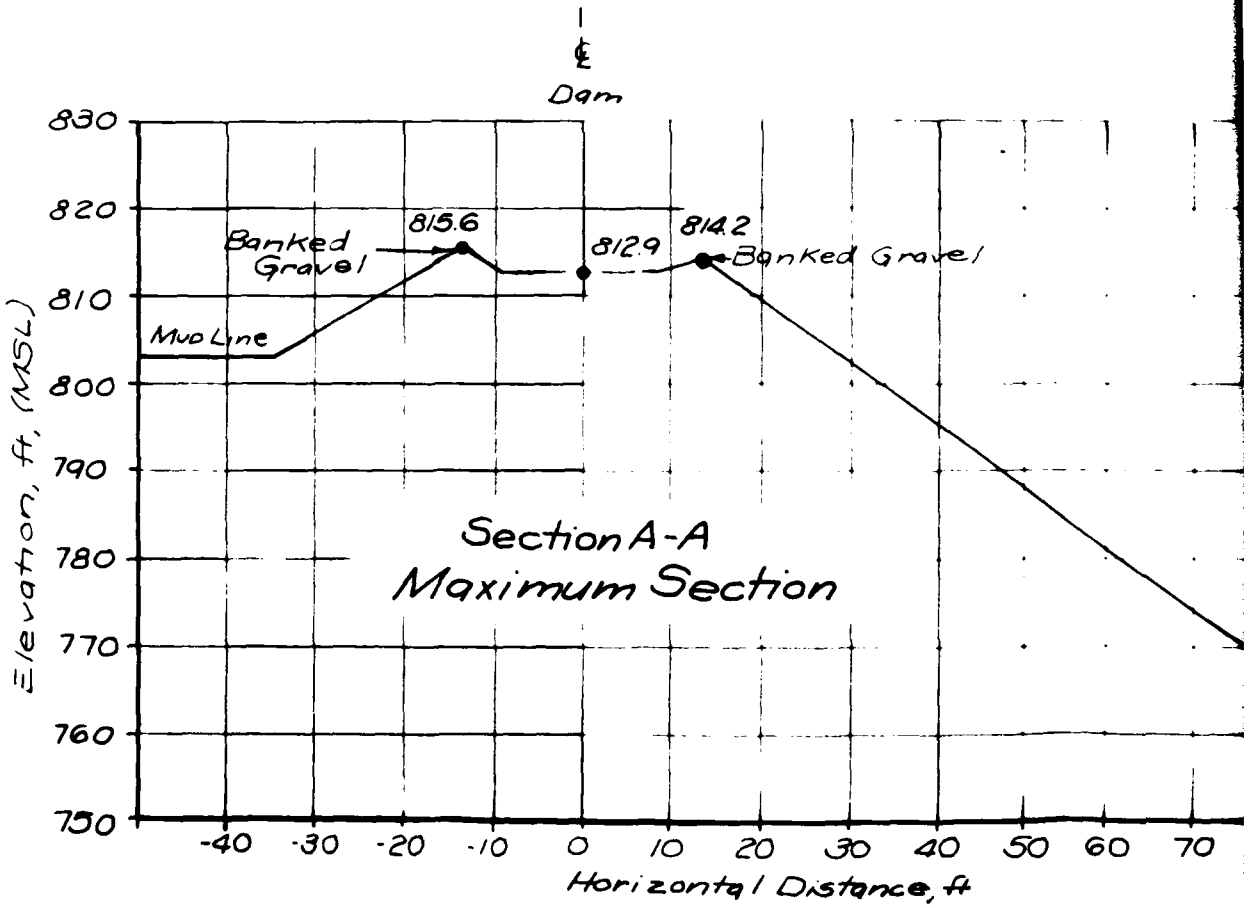
DRAINAGE BASIN AND SITE TOPOGRAPHY

LITTLE INDIAN CREEK DAM

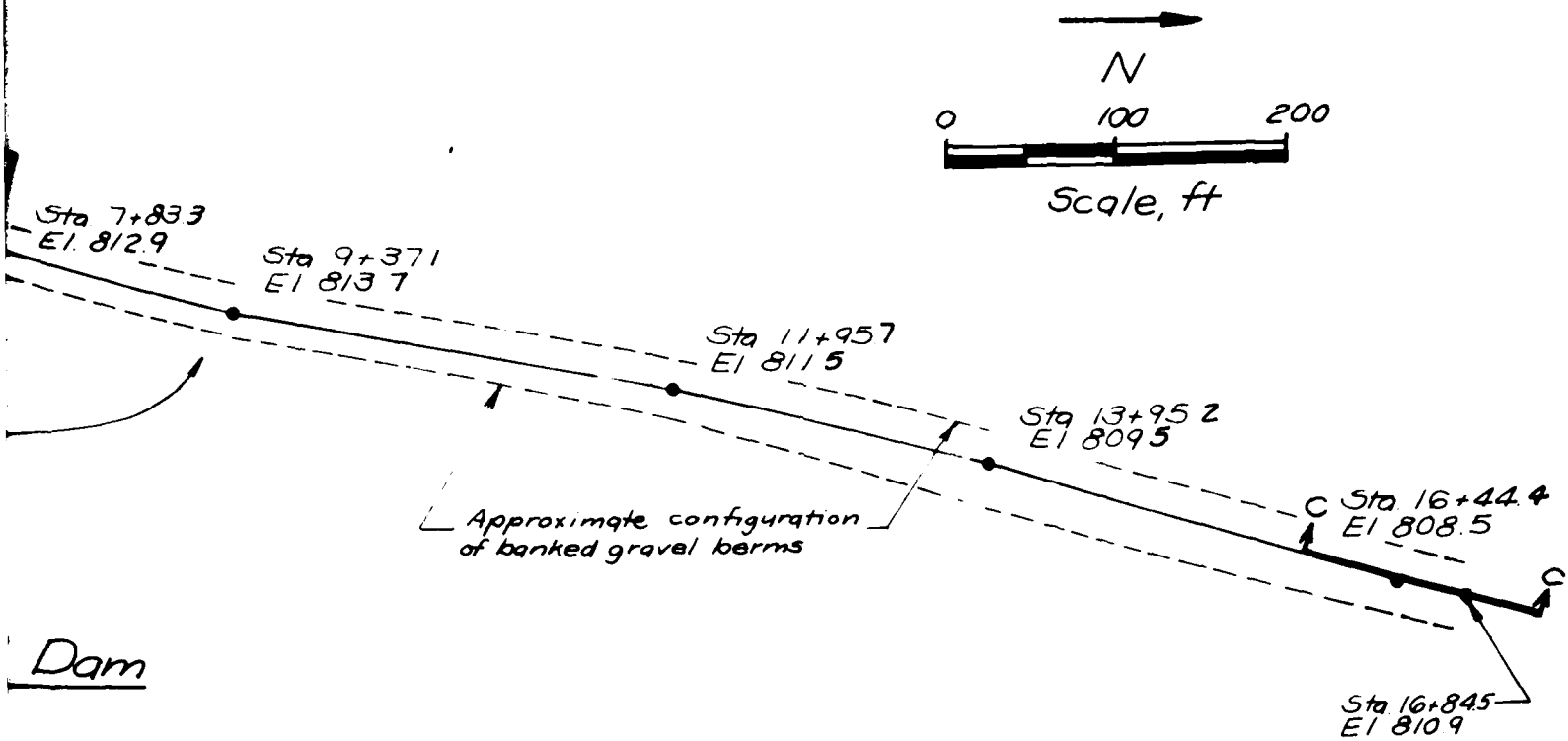
MO. 30718 | Fig. 2

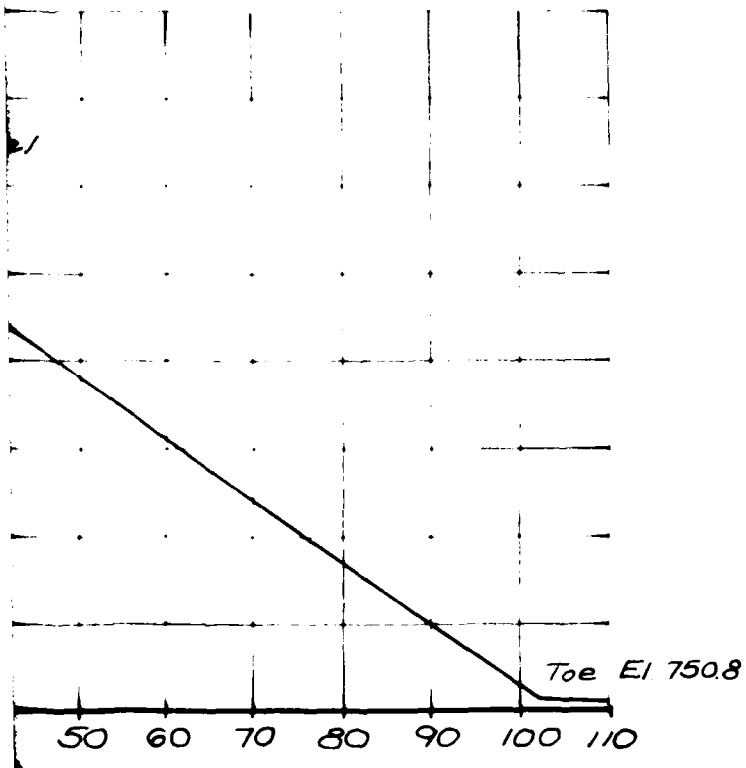


Plan of Dam

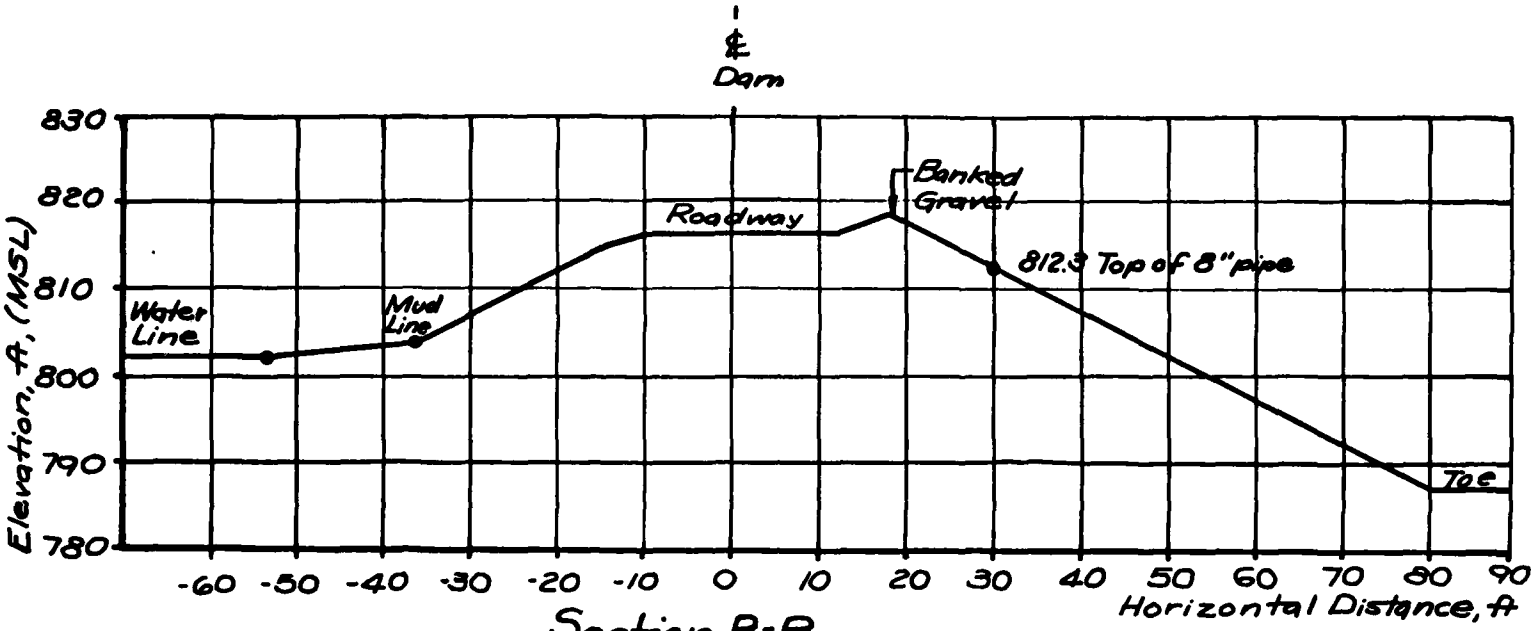


Section A-A
Maximum Section



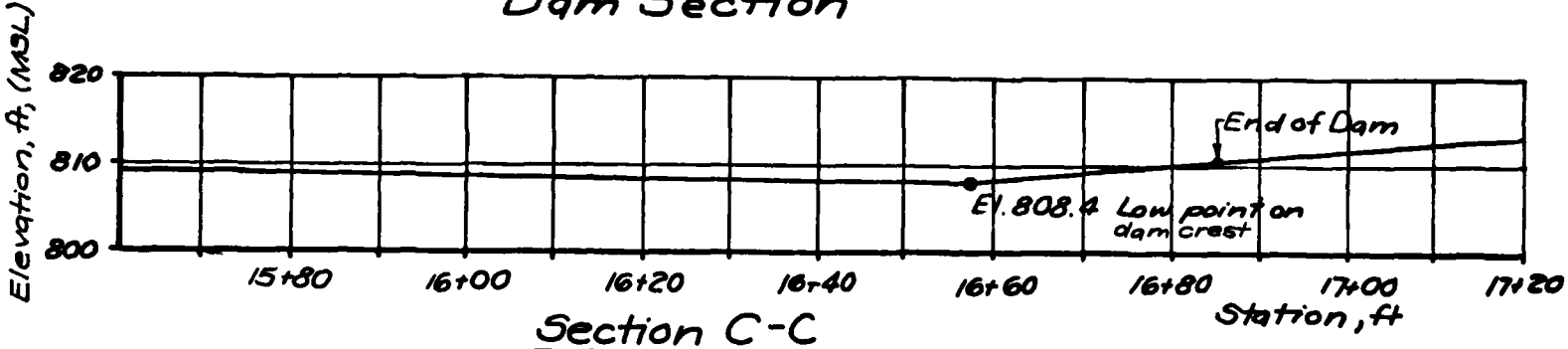


PLAN AND SECTION OF DAM	
LITTLE INDIAN CREEK DAM	
MO 30718	Fig. 3 A



Section B-B

Dam Section

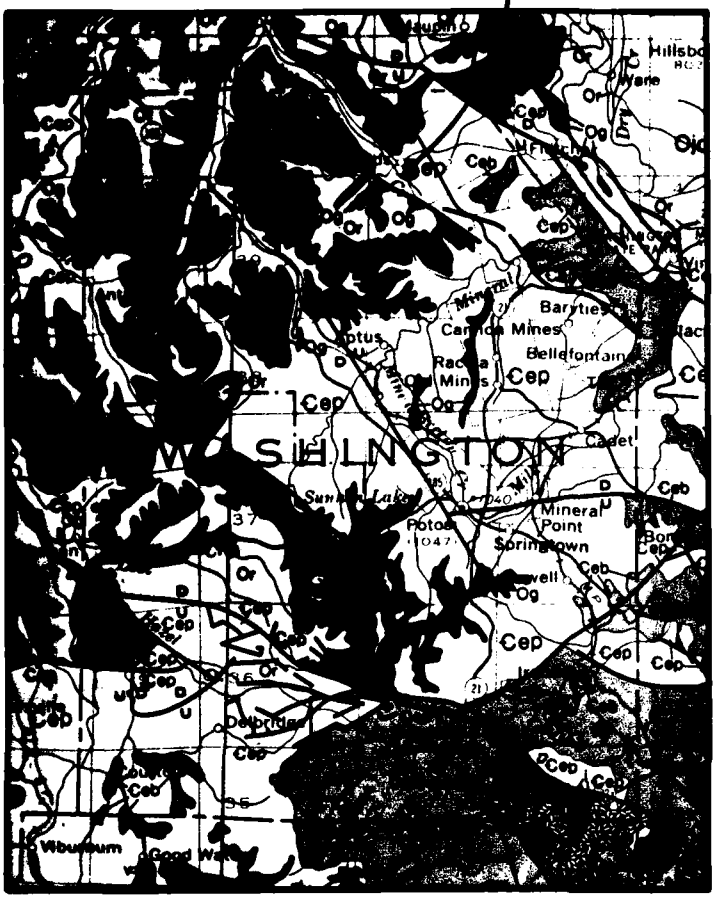


Section C-C

Low Point on Dam Crest Profile

SECTION OF DAM AND CREST PROFILE	
LITTLE INDIAN CREEK DAM	
MO 30718	Fig. 3 B

DAM LOCATION



Legend

Roubidoux Formation

Gasconade Dolomite
Gunter Sandstone Member

Eminence Dolomite

Potosi Dolomite

Derby-Doerun Dolomite

Davis Formation

Bonneterre Formation
Whetstone Creek Member
Sullivan Siltstone Member

Reagan Sandstone
(subsurface, western Missouri)

Lamotte Sandstone

Diabase (dikes and sills)

St. Francois Mountains Intrusive Suite

St. Francois Mountains Volcanic Supergroup

N

0 10 20

Scale, mile

REGIONAL GEOLOGIC MAP

LITTLE INDIAN CREEK DAM

MO. 30718 | Fig. 4

APPENDIX A

Photographs

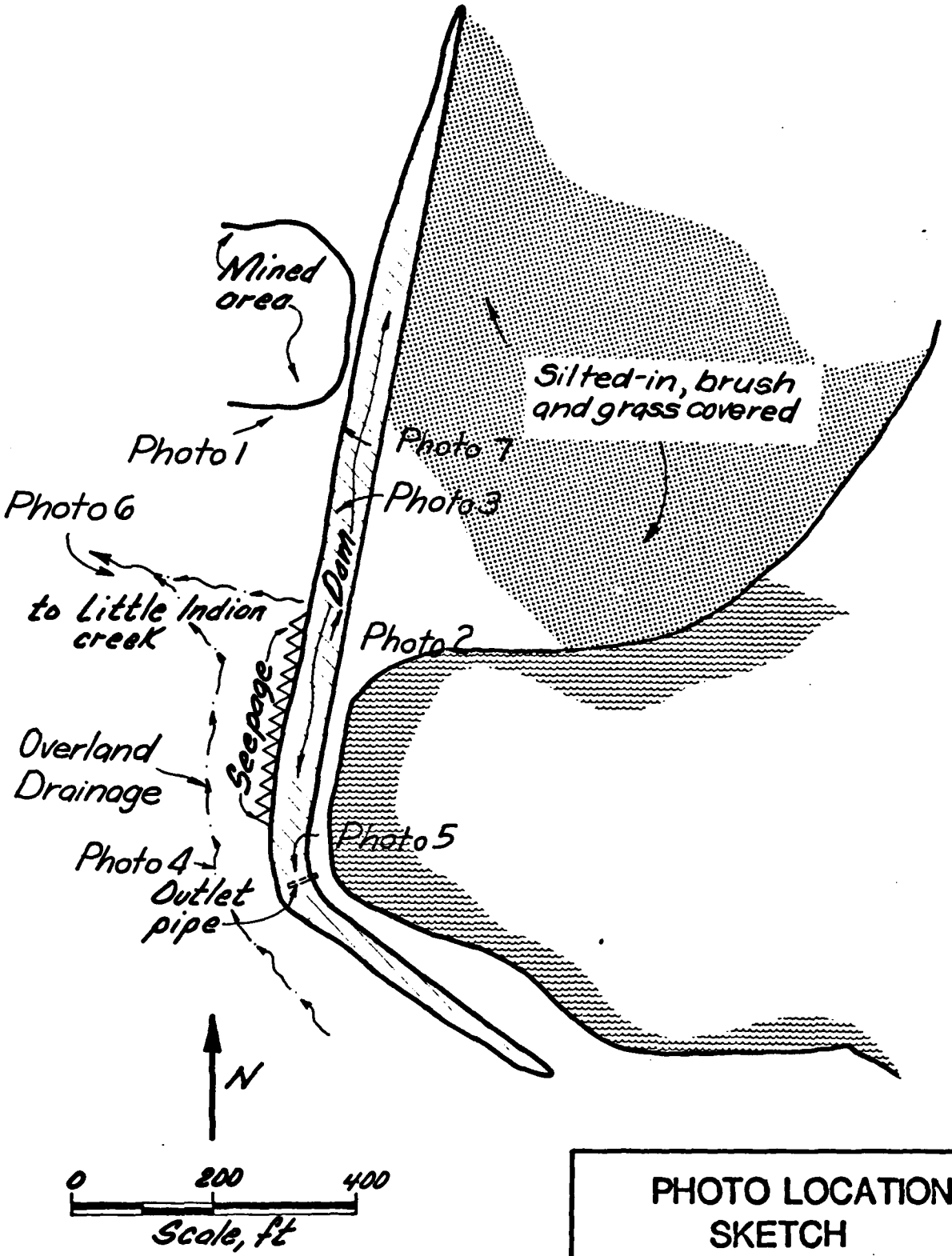
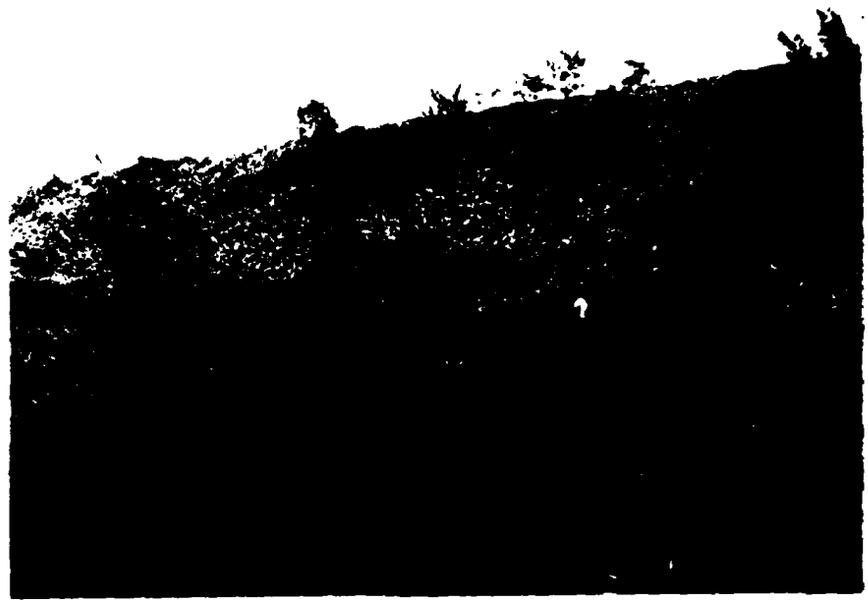


PHOTO LOCATION SKETCH

LITTLE INDIAN CREEK DAM

MO. 30718 | Fig. A-1



1. Bullrock (coarse tailings) on face of dam. Note mining cut face at toe of dam, left center. Looking northeast.

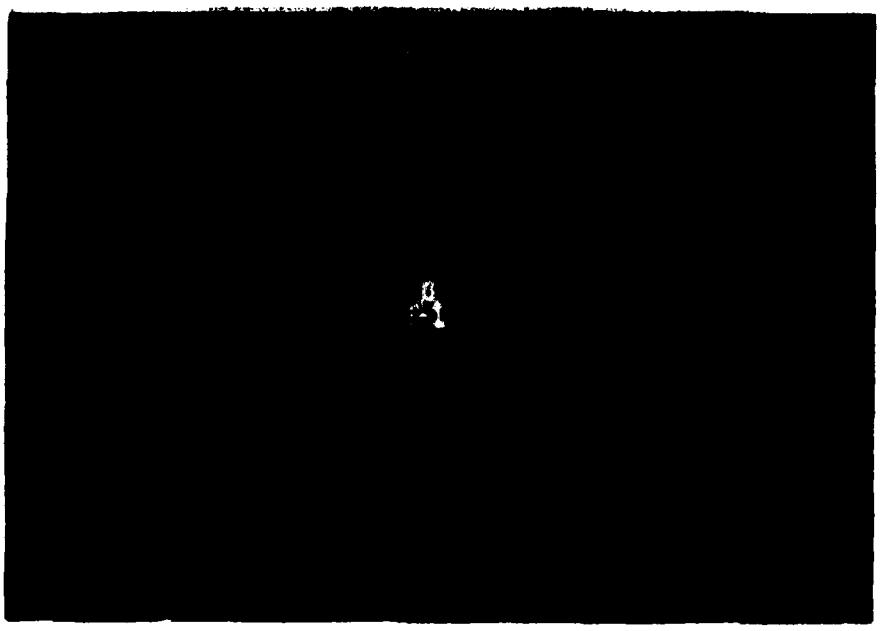
2. Roadway on crest of dam. Impoundment area to the right. Looking north.

3. Downstream face of dam. Note leaning trees indicating possible slumping of slope face. Looking southwest.

4. Overland drainage gully at toe of dam. Looking east.

5. Inoperative outlet pipe near south end of embankment. Looking south.

6. Total seepage and overland drainage below toe of dam. Looking east.



7. Downstream hazards, west end of town of Richwoods. Looking northwest from crest of dam.

APPENDIX B

Hydraulic/Hydrologic Data and Analyses

APPENDIX B
Hydraulic/Hydrologic Data and Analyses

B.1 Procedures

a. General. The hydraulic/hydrologic analyses were performed using the "HEC-1, Dam Safety Version (1 Apr 80)" computer program. The inflow hydrographs were developed for various precipitation events by applying them to a synthetic unit hydrograph. The inflow hydrographs were subsequently routed through the reservoir and appurtenant structures by the modified Puls reservoir routing option.

b. Precipitation events. The Probable Maximum Precipitation (PMP) and the 1 and 10 percent probability-of-occurrence events were used in the analyses. The total rainfall and corresponding distributions for the 1 and 10 percent probability events were provided by the St. Louis District, Corps of Engineers. The Probable Maximum Precipitation was determined from regional curves prepared by the US Weather Bureau (Hydrometeorological Report Number 33, 1956).

c. Unit hydrograph. The Soil Conservation Services (SCS) Dimensionless Unit Hydrograph method (National Engineering Handbook, Section 4, Hydrology, 1971) was used in the analysis. This method was selected because of its simplicity, applicability to drainage areas less than 10 mi^2, and its easy availability within the HEC-1 computer program.

The watershed lag time was computed using the SCS "curve number method" by an empirical relationship as follows:

$$L = \frac{l^{0.8}(s+1)^{0.7}}{1900\, Y^{0.5}} \quad \text{(Equation 15-4)}$$

where: L = lag in hours
l = hydraulic length of the watershed in feet
$s = \frac{1000}{CN} - 10$ where CN = hydrologic soil curve number
Y = average watershed land slope in percent

This empirical relationship accounts for the soil cover, average watershed slope and hydraulic length.

With the lag time thus computed, another empirical relationship is used to compute the time of concentration as follows:

$$T_c = \frac{L}{0.6} \quad \text{(Equation 15-3)}$$

where: T_c = time of concentration in hours

L = lag in hours.

Subsequent to the computation of the time of concentration, the unit hydrograph duration was estimated utilizing the following relationship:

$$\Delta D = 0.133 T_c \qquad \text{(Equation 16-12)}$$

where: ΔD = duration of unit excess rainfall
T_c = time of concentration in hours.

The final interval was selected to provide at least three discharge ordinates prior to the peak discharge ordinate of the unit hydrograph. For this dam, a time interval of 10 minutes was used.

d. Infiltration losses. The infiltration losses were computed by the HEC-1 computer program internally using the SCS curve number method. The curve numbers were established taking into consideration the variables of: (a) antecedent moisture condition, (b) hydrologic soil group classification, (c) degree of development, (d) vegetative cover and (e) present land usage in the watershed.

Antecedent moisture condition III (AMC III) was used for the PMF estimates and AMC II was used for the 1 and 10 percent probability events, in accordance with the guidelines. The remaining variables are defined in the SCS procedure and judgements in their selection were made on the basis of visual field inspection.

e. Starting elevations. Reservoir starting water surface elevations for this dam were set as follows:

(1) 1 and 10 percent probability events - high water mark elevation of 803.4 ft.

(2) Probable Maximum Storm - minimum top of dam elevation of 808.4 ft.

f. Spillway rating curve. No spillway is present at this dam.

B.2 Pertinent Data

a. Drainage area. 0.63 mi^2

b. Storm duration. A unit hydrograph was developed by the SCS method option of HEC-1 program. The design storm of 48 hours duration was divided into 10 minute intervals in order to develop the inflow hydrograph.

c. Lag time. 1.47 hrs.

d. Hydrologic soil group. C

e. SCS curve numbers.

1. For PMF- AMC III - Curve Number 89
2. For 1 and 10 percent probability-of-occurrence events AMC II - Curve Number 77

f. Storage. Elevation-area data were developed by planimetering areas at various elevation contours on the USGS Richwoods NE 7.5 minute quadrangle map. The data were entered on the $A and $E cards so that the HEC-1 program could compute storage volumes.

g. Outflow over dam crest. As the profile of the dam crest is irregular, flow over the crest was computed according to the "Flow Over Non-Level Dam Crest" supplement to the HEC-1 User's Manual. The crest length-elevation data and hydraulic constants were entered on the $D, $L, and $V cards.

h. Outflow capacity. The overflow rating curve was computed by the intrinsic formula within the HEC-1 program, with pertinent data entered on the $$ card.

i. Reservoir elevations. For the 50 and 100 percent of the PMF events, the starting reservoir elevation was 808.4 ft, the low area on the dam crest. For the 1 and 10 percent probability-of-occurrence events, the starting reservoir elevation was 803.4 ft, the elevation of the high water line in the reservoir area.

B.3 Results

The results of the analyses as well as the input values to the HEC-1 program follow in this Appendix. Only the results summaries are included, not the intermediate output. Complete copies of the HEC-1 output are available in the project files.

```
**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  01 APR 80
**********
     1                A1       DAM NO. 30719 - SOUTHEAST OF RICHWOODS, WASHINGTON COUNTY, MISSOURI.
     2                A2       WOODWARD-CLYDE CONSULTANTS, HOUSTON JOB 79CH009.
     3                A3       PROBABLE MAXIMUM FLOODS (PMF) ANALYSIS.
     4                B     288        3       10       -0       -0       -0       -0       -0       -0       -0
     5                B1      5
     6                J       1        4        1
     7                J1   .25      .50      .75     1.00
     8                K       0     6-HR                                                  1
     9                KK  DAM NO. 30718 (DESOTO MINING CO.) - MULTI-RATIO PMF RUNOFF COMPUTATIONS.
    10                M       1        2   0.627                                        1                   1
    11                P       0      26.      102      120      130      140
    12                T                                                                -1      -09             0.105
    13                W2          1.465
    14                X      -1     -.05        3
    15                K       1      DAM                                2                1
    16                K1  DAM NO. 30718 (DESOTO CO.) - MULTI-RATIO PMF CAPACITY/OVERTOPPING ANALYSES.
    17                V                                                1        1
    18                V1      1                                                                  808.4
    19                SA      1.     10.9     33.8     47.5     48.7     70.4
    20                SE   785.     790.     800.     808.4    810.     820.
    21                S1  808.4       0.      2.9      1.5
    22                SD  808.4      2.8      1.5
    23                SL      0.     60.     100.     260.     400.     530.     655.     765.    1285.    1435.
    24                SV  808.4    809.0    809.5     810.     811.     812.     813.     814.     815.     816.
    25                K      99
```

Input Data
Various PMF Events
Little Indian Creek Dam
MO 30718

FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION JULY 1978
LAST MODIFICATION 01 APR 80

RUN DATE: 19 JUN 80
TIME: 12.01.06

DAM NO. 30718 - SOUTHEAST OF RICHWOODS, WASHINGTON COUNTY, MISSOURI.
WOODWARD-CLYDE CONSULTANTS, HOUSTON JOB 79CH009.
PROBABLE MAXIMUM FLOODS (PMP) ANALYSIS.

JOB SPECIFICATION

NQ	NMR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
288	0	10	-0	-0	-0	-0	-0	-0	-0

JOPER NWT LROPT TRACE
5 -0 -0 -0

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NRTIO= 4 LRTIO= 1
RTIOS= .25 .50 .75 1.00

SUB-AREA RUNOFF COMPUTATION

DAM NO. 30718 (DESOTO MINING CO.) - MULTI-RATIO PMF RUNOFF COMPUTATIONS.

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
Q-IN	0	-0	-0	-0	-0	1	-0	-0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	2	.63	-0.	.63	1.00	-0.	-0	1	-0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.	26.00	102.00	120.00	130.00	140.00	-0.	-0.

LOSS DATA

LRTPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
-0	-0.	-0.	1.00	-0.	-0.	1.00	-1.00	-89.00	-0.	.11

CURVE NO = -89.00 HETNESS = -1.00 EFFECT CN = 89.00

UNIT HYDROGRAPH DATA
TC= -0. LAG= 1.47

RECESSION DATA
STRTQ= -1.00 QRCSN= -.05 RTIOR= 3.00

UNIT HYDROGRAPH 46 END OF PERIOD ORDINATES, TC= -0. HOURS, LAG= 1.47 VOL= 1.00

7.	22.	41.	70.	106.	143.	172.	189.	195.	196.
184.	169.	151.	131.	107.	87.	73.	61.	52.	44.
37.	31.	26.	22.	18.	15.	13.	11.	9.	8.
6.	5.	4.	4.	3.	3.	2.	2.	2.	1.
1.	1.	1.	1.	0.	0.				

Input Data
Various PMF Events
Little Indian Creek Dam
MO 30718

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.10	1	.00	.00	.00	1.	1.02	.10	145	.03	.03	.00	8.
1.01	.20	2	.00	.00	.00	1.	1.02	.20	146	.03	.03	.00	8.
1.01	.30	3	.00	.00	.00	0.	1.02	.30	147	.03	.03	.00	9.
1.01	.40	4	.00	.00	.00	0.	1.02	.40	148	.03	.03	.00	11.
1.01	.50	5	.00	.00	.00	0.	1.02	.50	149	.03	.03	.00	13.
1.01	1.00	6	.00	.00	.00	0.	1.02	1.00	150	.03	.03	.00	16.
1.01	1.10	7	.00	.00	.00	0.	1.02	1.10	151	.03	.03	.00	20.
1.01	1.20	8	.00	.00	.00	0.	1.02	1.20	152	.03	.03	.00	25.
1.01	1.30	9	.00	.00	.00	0.	1.02	1.30	153	.03	.03	.00	29.
1.01	1.40	10	.00	.00	.00	0.	1.02	1.40	154	.03	.03	.00	33.
1.01	1.50	11	.00	.00	.00	0.	1.02	1.50	155	.03	.03	.00	38.
1.01	2.00	12	.00	.00	.00	1.	1.02	2.00	156	.03	.03	.00	42.
1.01	2.10	13	.00	.00	.00	1.	1.02	2.10	157	.03	.03	.00	45.
1.01	2.20	14	.00	.00	.00	1.	1.02	2.20	158	.03	.03	.00	48.
1.01	2.30	15	.00	.00	.00	1.	1.02	2.30	159	.03	.03	.00	51.
1.01	2.40	16	.00	.00	.00	1.	1.02	2.40	160	.03	.03	.00	53.
1.01	2.50	17	.00	.00	.00	1.	1.02	2.50	161	.03	.03	.00	55.
1.01	3.00	18	.00	.00	.00	1.	1.02	3.00	162	.03	.03	.00	56.
1.01	3.10	19	.00	.00	.00	1.	1.02	3.10	163	.03	.03	.00	57.
1.01	3.20	20	.00	.00	.00	1.	1.02	3.20	164	.03	.03	.00	58.
1.01	3.30	21	.00	.00	.00	1.	1.02	3.30	165	.03	.03	.00	59.
1.01	3.40	22	.00	.00	.00	1.	1.02	3.40	166	.03	.03	.00	60.
1.01	3.50	23	.00	.00	.00	1.	1.02	3.50	167	.03	.03	.00	61.
1.01	4.00	24	.00	.00	.00	1.	1.02	4.00	168	.03	.03	.00	61.
1.01	4.10	25	.00	.00	.00	1.	1.02	4.10	169	.03	.03	.00	62.
1.01	4.20	26	.00	.00	.00	1.	1.02	4.20	170	.03	.03	.00	62.
1.01	4.30	27	.00	.00	.00	1.	1.02	4.30	171	.03	.03	.00	63.
1.01	4.40	28	.00	.00	.00	1.	1.02	4.40	172	.03	.03	.00	63.
1.01	4.50	29	.00	.00	.00	1.	1.02	4.50	173	.03	.03	.00	63.
1.01	5.00	30	.00	.00	.00	1.	1.02	5.00	174	.03	.03	.00	64.
1.01	5.10	31	.00	.00	.00	1.	1.02	5.10	175	.03	.03	.00	64.
1.01	5.20	32	.00	.00	.00	1.	1.02	5.20	176	.03	.03	.00	64.
1.01	5.30	33	.00	.00	.00	1.	1.02	5.30	177	.03	.03	.00	64.
1.01	5.40	34	.00	.00	.00	1.	1.02	5.40	178	.03	.03	.00	64.
1.01	5.50	35	.00	.00	.00	1.	1.02	5.50	179	.03	.03	.00	64.
1.01	6.00	36	.00	.00	.00	1.	1.02	6.00	180	.03	.03	.00	65.
1.01	6.10	37	.01	.00	.01	1.	1.02	6.10	181	.13	.12	.01	65.
1.01	6.20	38	.01	.00	.01	1.	1.02	6.20	182	.13	.12	.01	68.
1.01	6.30	39	.01	.00	.01	1.	1.02	6.30	183	.13	.12	.01	77.
1.01	6.40	40	.01	.00	.01	1.	1.02	6.40	184	.13	.12	.01	79.
1.01	6.50	41	.01	.00	.01	1.	1.02	6.50	185	.13	.12	.01	89.
1.01	7.00	42	.01	.00	.01	1.	1.02	7.00	186	.13	.12	.01	109.
1.01	7.10	43	.01	.00	.01	1.	1.02	7.10	187	.13	.12	.01	119.
1.01	7.20	44	.01	.00	.01	1.	1.02	7.20	188	.13	.12	.01	137.
1.01	7.30	45	.01	.00	.01	1.	1.02	7.30	189	.13	.12	.01	156.
1.01	7.40	46	.01	.00	.01	2.	1.02	7.40	190	.13	.12	.01	175.
1.01	7.50	47	.01	.00	.01	2.	1.02	7.50	191	.13	.13	.00	193.
1.01	8.00	48	.01	.00	.01	2.	1.02	8.00	192	.13	.13	.00	209.
1.01	8.10	49	.01	.00	.01	2.	1.02	8.10	193	.13	.13	.00	224.
1.01	8.20	50	.01	.00	.01	2.	1.02	8.20	194	.13	.13	.00	237.
1.01	8.30	51	.01	.00	.01	2.	1.02	8.30	195	.13	.13	.00	248.
1.01	8.40	52	.01	.00	.01	2.	1.02	8.40	196	.13	.13	.00	257.
1.01	8.50	53	.01	.00	.01	2.	1.02	8.50	197	.13	.13	.00	264.
1.01	9.00	54	.01	.00	.01	2.	1.02	9.00	198	.13	.13	.00	271.
1.01	9.10	55	.01	.00	.01	2.	1.02	9.10	199	.13	.13	.00	276.
1.01	9.20	56	.01	.00	.01	2.	1.02	9.20	200	.13	.13	.00	281.
1.01	9.30	57	.01	.00	.01	2.	1.02	9.30	201	.13	.13	.00	285.
1.01	9.40	58	.01	.00	.01	2.	1.02	9.40	202	.13	.13	.00	288.
1.01	9.50	59	.01	.00	.01	3.	1.02	9.50	203	.13	.13	.00	291.
1.01	10.00	60	.01	.00	.01	3.	1.02	10.00	204	.13	.13	.00	294.

1.01	10.10	1	.01	.00	.01	3.	1.02	10.10	205	.13	.13	.00	296.
1.01	10.20	2	.01	.00	.01	3.	1.02	10.20	206	.13	.13	.00	298.
1.01	10.30	63	.01	.00	.01	3.	1.02	10.30	207	.13	.13	.00	299.
1.01	10.40	64	.01	.00	.01	3.	1.02	10.40	208	.13	.13	.00	301.
1.01	10.50	65	.01	.00	.01	3.	1.02	10.50	209	.13	.13	.00	302.
1.01	11.00	66	.01	.00	.01	4.	1.02	11.00	210	.13	.13	.00	303.
1.01	11.10	67	.01	.00	.01	4.	1.02	11.10	211	.13	.13	.00	304.
1.01	11.20	68	.01	.00	.01	4.	1.02	11.20	212	.13	.13	.00	305.
1.01	11.30	69	.01	.00	.01	4.	1.02	11.30	213	.13	.13	.00	305.
1.01	11.40	70	.01	.00	.01	5.	1.02	11.40	214	.13	.13	.00	306.
1.01	11.50	71	.01	.00	.01	5.	1.02	11.50	215	.13	.13	.00	307.
1.01	12.00	72	.01	.00	.01	5.	1.02	12.00	216	.13	.13	.00	309.
1.01	12.10	73	.03	.01	.02	5.	1.02	12.10	217	.44	.44	.01	310.
1.01	12.20	74	.03	.01	.02	6.	1.02	12.20	218	.44	.44	.01	317.
1.01	12.30	75	.03	.01	.02	7.	1.02	12.30	219	.44	.44	.01	330.
1.01	12.40	76	.03	.01	.02	7.	1.02	12.40	220	.44	.44	.01	352.
1.01	12.50	77	.03	.02	.02	9.	1.02	12.50	221	.44	.44	.00	385.
1.01	13.00	78	.03	.02	.02	10.	1.02	13.00	222	.44	.44	.00	430.
1.01	13.10	79	.04	.02	.02	12.	1.02	13.10	223	.53	.53	.00	484.
1.01	13.20	80	.04	.02	.02	15.	1.02	13.20	224	.53	.53	.00	544.
1.01	13.30	81	.04	.02	.02	17.	1.02	13.30	225	.53	.53	.00	608.
1.01	13.40	82	.04	.02	.02	20.	1.02	13.40	226	.53	.53	.00	675.
1.01	13.50	83	.04	.02	.02	23.	1.02	13.50	227	.53	.53	.00	741.
1.01	14.00	84	.04	.02	.02	27.	1.02	14.00	228	.53	.53	.00	806.
1.01	14.10	85	.05	.03	.02	30.	1.02	14.10	229	.66	.66	.00	870.
1.01	14.20	86	.05	.03	.02	33.	1.02	14.20	230	.66	.66	.00	931.
1.01	14.30	87	.05	.03	.02	37.	1.02	14.30	231	.66	.66	.00	987.
1.01	14.40	88	.05	.03	.02	40.	1.02	14.40	232	.66	.66	.00	1041.
1.01	14.50	89	.05	.04	.02	44.	1.02	14.50	233	.66	.66	.00	1094.
1.01	15.00	90	.05	.04	.01	48.	1.02	15.00	234	.66	.66	.00	1147.
1.01	15.10	91	.09	.07	.01	51.	1.02	15.10	235	.60	.60	.00	1199.
1.01	15.20	92	.08	.06	.02	55.	1.02	15.20	236	1.01	1.00	.00	1251.
1.01	15.30	93	.14	.11	.03	60.	1.02	15.30	237	1.81	1.81	.01	1310.
1.01	15.40	94	.23	.20	.03	67.	1.02	15.40	238	4.53	4.52	.01	1403.
1.01	15.50	95	.10	.08	.02	76.	1.02	15.50	239	1.31	1.31	.00	1537.
1.01	16.00	96	.06	.05	.01	87.	1.02	16.00	240	.81	.80	.00	1703.
1.01	16.10	97	.05	.04	.01	101.	1.02	16.10	241	.62	.62	.00	1904.
1.01	16.20	98	.05	.04	.01	117.	1.02	16.20	242	.62	.62	.00	2145.
1.01	16.30	99	.05	.04	.01	133.	1.02	16.30	243	.62	.62	.00	2374.
1.01	16.40	100	.05	.04	.01	146.	1.02	16.40	244	.62	.62	.00	2550.
1.01	16.50	101	.05	.04	.01	154.	1.02	16.50	245	.62	.62	.00	2658.
1.01	17.00	102	.05	.04	.01	159.	1.02	17.00	246	.62	.62	.00	2699.
1.01	17.10	103	.04	.03	.00	160.	1.02	17.10	247	.49	.49	.00	2694.
1.01	17.20	104	.04	.03	.00	158.	1.02	17.20	248	.49	.49	.00	2625.
1.01	17.30	105	.04	.03	.00	154.	1.02	17.30	249	.49	.49	.00	2531.
1.01	17.40	106	.04	.03	.00	148.	1.02	17.40	250	.49	.49	.00	2413.
1.01	17.50	107	.04	.03	.00	140.	1.02	17.50	251	.49	.49	.00	2267.
1.01	18.00	108	.04	.03	.00	131.	1.02	18.00	252	.49	.49	.00	2106.
1.01	18.10	109	.00	.00	.00	123.	1.02	18.10	253	.04	.04	.00	1968.
1.01	18.20	110	.00	.00	.00	116.	1.02	18.20	254	.04	.04	.00	1838.
1.01	18.30	111	.00	.00	.00	110.	1.02	18.30	255	.04	.04	.00	1720.
1.01	18.40	112	.00	.00	.00	103.	1.02	18.40	256	.04	.04	.00	1605.
1.01	18.50	113	.00	.00	.00	96.	1.02	18.50	257	.04	.04	.00	1486.
1.01	19.00	114	.00	.00	.00	88.	1.02	19.00	258	.04	.04	.00	1357.
1.01	19.10	115	.00	.00	.00	79.	1.02	19.10	259	.04	.04	.00	1224.
1.01	19.20	116	.00	.00	.00	71.	1.02	19.20	260	.04	.04	.00	1092.
1.01	19.30	117	.00	.00	.00	63.	1.02	19.30	261	.04	.04	.00	965.
1.01	19.40	118	.00	.00	.00	55.	1.02	19.40	262	.04	.04	.00	847.
1.01	19.50	119	.00	.00	.00	48.	1.02	19.50	263	.04	.04	.00	737.
1.01	20.00	120	.00	.00	.00	42.	1.02	20.00	264	.04	.04	.00	639.
1.01	20.10	121	.00	.00	.00	36.	1.02	20.10	265	.04	.04	.00	552.
1.01	20.20	122	.00	.00	.00	31.	1.02	20.20	266	.04	.04	.00	477.
1.01	20.30	123	.00	.00	.00	27.	1.02	20.30	267	.04	.04	.00	416.

1.01	20.	122	.00	.00	.00	31.	1.02	20.20	266	.04	.04	.00	477.
1.01	20.10	123	.00	.00	.00	27.	1.02	20.30	267	.04	.04	.00	416.
1.01	20.20	124	.00	.00	.00	24.	1.02	20.40	268	.04	.04	.00	367.
1.01	20.30	125	.00	.00	.00	21.	1.02	20.50	269	.04	.04	.00	325.
1.01	20.40	126	.00	.00	.00	19.	1.02	21.00	270	.04	.04	.00	289.
1.01	20.50	127	.00	.00	.00	17.	1.02	21.10	271	.04	.04	.00	260.
1.01	21.00	128	.00	.00	.00	16.	1.02	21.20	272	.04	.04	.00	234.
1.01	21.10	129	.00	.00	.00	14.	1.02	21.30	273	.04	.04	.00	213.
1.01	21.20	130	.00	.00	.00	13.	1.02	21.40	274	.04	.04	.00	198.
1.01	21.30	131	.00	.00	.00	12.	1.02	21.50	275	.04	.04	.00	181.
1.01	21.40	132	.00	.00	.00	11.	1.02	22.00	276	.04	.04	.00	169.
1.01	21.50	133	.00	.00	.00	11.	1.02	22.10	277	.04	.04	.00	159.
1.01	22.00	134	.00	.00	.00	10.	1.02	22.20	278	.04	.04	.00	150.
1.01	22.10	135	.00	.00	.00	10.	1.02	22.30	279	.04	.04	.00	142.
1.01	22.20	136	.00	.00	.00	9.	1.02	22.40	280	.04	.04	.00	135.
1.01	22.30	137	.00	.00	.00	9.	1.02	22.50	281	.04	.04	.00	130.
1.01	23.00	138	.00	.00	.00	8.	1.02	23.00	282	.04	.04	.00	125.
1.01	23.10	139	.00	.00	.00	8.	1.02	23.10	283	.04	.04	.00	120.
1.01	23.20	140	.00	.00	.00	8.	1.02	23.20	284	.04	.04	.00	117.
1.01	23.30	141	.00	.00	.00	8.	1.02	23.30	285	.04	.04	.00	115.
1.01	23.40	142	.00	.00	.00	8.	1.02	23.40	286	.04	.04	.00	113.
1.01	23.50	143	.00	.00	.00	8.	1.02	23.50	287	.04	.04	.00	111.
1.02	0.	144	.00	.00	.00	8.	1.03	0.	288	.04	.04	.00	110.
								SUM	36.40	35.11	1.29	84030.
									(925.1(	892.1(	33.1(	2379.461

Input Data
Various PMF Events
Little Indian Creek Dam
MO 30718

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS RATIO 1 .25	RATIO 2 .50	RATIO 3 .75	RATIO 4 1.00
HYDROGRAPH AT	O-IN	.63	1	675.	1349.	2024.	2699.
		(1.62)	(	19.10)(	38.21)(	57.31)(	76.42)(
ROUTED TO	DAM	.63	1	600.	1278.	1950.	2628.
		(1.62)	(	16.99)(	36.20)(	55.23)(	74.42)(

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1		INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
	ELEVATION	808.40	808.40	808.40
	STORAGE	578.	578.	578.
	OUTFLOW	0.	0.	0.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.25	810.19	1.79	665.	600.	48.00	41.67	0.
.50	810.71	2.31	690.	1279.	48.00	41.50	0.
.75	811.09	2.69	709.	1950.	48.00	41.33	0.
1.00	811.34	2.94	725.	2628.	48.00	41.33	0.

Output Summary
Various PMF Events
Little Indian Creek Dam
MO 30718

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

				RATIOS APPLIED TO FLOWS
OPERATION	STATION	AREA	PLAN	RATIO 1
				.12
HYDROGRAPH AT	LAKE	.63	1	324.
		(1.62)		(9.17)
ROUTED TO	DAM	.63	1	0.
		(1.62)		(0.)

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1		INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
	ELEVATION	805.13	808.40	808.40
	STORAGE	432.	578.	578.
	OUTFLOW	0.	0.	0.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.12	808.27	0.	572.	0.	0.	0.	0.

Overtopping Analysis
12% PMF Event
Little Indian Creek
MO 30718


FILME